Fishery Data Series No. 93-54

Lower Kenai Peninsula Dolly Varden and Steelhead Trout Studies During 1992

by

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Alaska Department of Fish and Game

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ABSTRACT

During the period 4 July to 1 October 1992, abundance, composition, and selected fishery statistics were estimated for Dolly Varden *Salvelinus malma* (Walbaum) and steelhead/rainbow trout *Oncorhynchus mykiss* on the Anchor River. A total of 10,051 Dolly Varden and 1,261 steelhead/rainbow trout were counted through a weir located 1.5 kilometers upstream from salt water on the Anchor River. The total immigration of Dolly Varden is the lowest total return documented since this study was begun in 1987. Post spawner Dolly Varden were observed entering the Anchor River during September and may signify that the Anchor River is an important overwintering location for other drainages.

KEY WORDS: Anchor River, Kenai Peninsula, anadromous, Dolly Varden, weir, age composition, sex composition, maturity index, *Salvelinus malma*, *Oncorhynchus mykiss*, population dynamics, mortality, survival.

INTRODUCTION

The Anchor River on the lower Kenai Peninsula (Figure 1) supports recreational fishing for chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, Dolly Varden *Salvelinus malma*, and anadromous (steelhead) and resident rainbow trout *O. mykiss*. The downstream section of this stream is crossed by the Sterling Highway making it easily accessible to the fishing public. Much of the river frontage along the lower 3 km of this stream is publicly owned, providing ample camping and parking areas. Due to the relatively small size of this stream, all fishing is conducted from the bank. The Anchor River has provided an average of 31,111 recreational fishing days (angler-days) annually from 1977 through 1991 (Mills 1979-1992). The fisheries targeting chinook salmon, coho salmon, steelhead, and Dolly Varden are of major importance to recreational anglers on the Anchor River, whereas the fisheries targeting resident rainbow trout and pink salmon are of lesser importance.

The recreational fishery for Dolly Varden in the Anchor River is one of the largest in Alaska and is of particular concern to resource managers. During the period 1977 to 1983, the harvest from this fishery averaged nearly 15,000 fish annually (Mills 1979-1984). In 1984, regulations for this fishery became more restrictive, bag and possession limits were reduced from ten to five fish, and the use of bait was prohibited after 16 September. While these regulations were in effect, the harvest of Dolly Varden averaged approximately 3,700 fish (Table 1). Although a marked decline was observed in the harvest of Dolly Varden after initiation of the new regulations, concerns were expressed that the decline may reflect a depressed population. During 1990, the use of bait was prohibited during the period 15 August through 31 December (ADF&G 1990). In 1991, regulations further restricted the daily bag limit from five to two fish and the use of bait was prohibited during the period 1 September through 31 December (ADF&G 1991). These same regulations remained in effect during 1992.

The reduction in bag limit from five to two Dolly Varden was implemented on the Anchor River, Deep Creek, Stariski Creek, and the Ninilchik River to protect the Dolly Varden spawning stock of the lower Kenai Peninsula. There was evidence from the Statewide Harvest Survey that harvests of Dolly Varden in the late 1970s and early 1980s exceeded recent levels of total abundance on these streams. A weir was established on the Anchor River in 1987, providing estimates of total abundance of the Dolly Varden immigration. The number of spawners in the immigration was also estimated at the weir. Since 1987, the spawner exploitation rate in the sport fishery ranged from 17% to 32% and averaged 25% (Larson 1990). Catch rates[1] from 1987 through 1989 averaged 57% of the total abundance and were highest (70%) in 1988. Thus, in addition to removing up to one-third of the spawners each year, a large number of fish were also hooked and released and it was suspected that mortality among these fish was high. The 70% catch rate and 32% spawner exploitation rate in 1988 occurred predominantly on the 300 mm to 349 mm length cohort. That same cohort, 1 year later, was depressed to less than half the expected abundance. These data, along with the continuing decline in abundance at the weir, suggested that a reduction in exploitation was necessary to protect the major lower Kenai Peninsula spawning stocks.

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[1] Fraction of the total population that was caught.

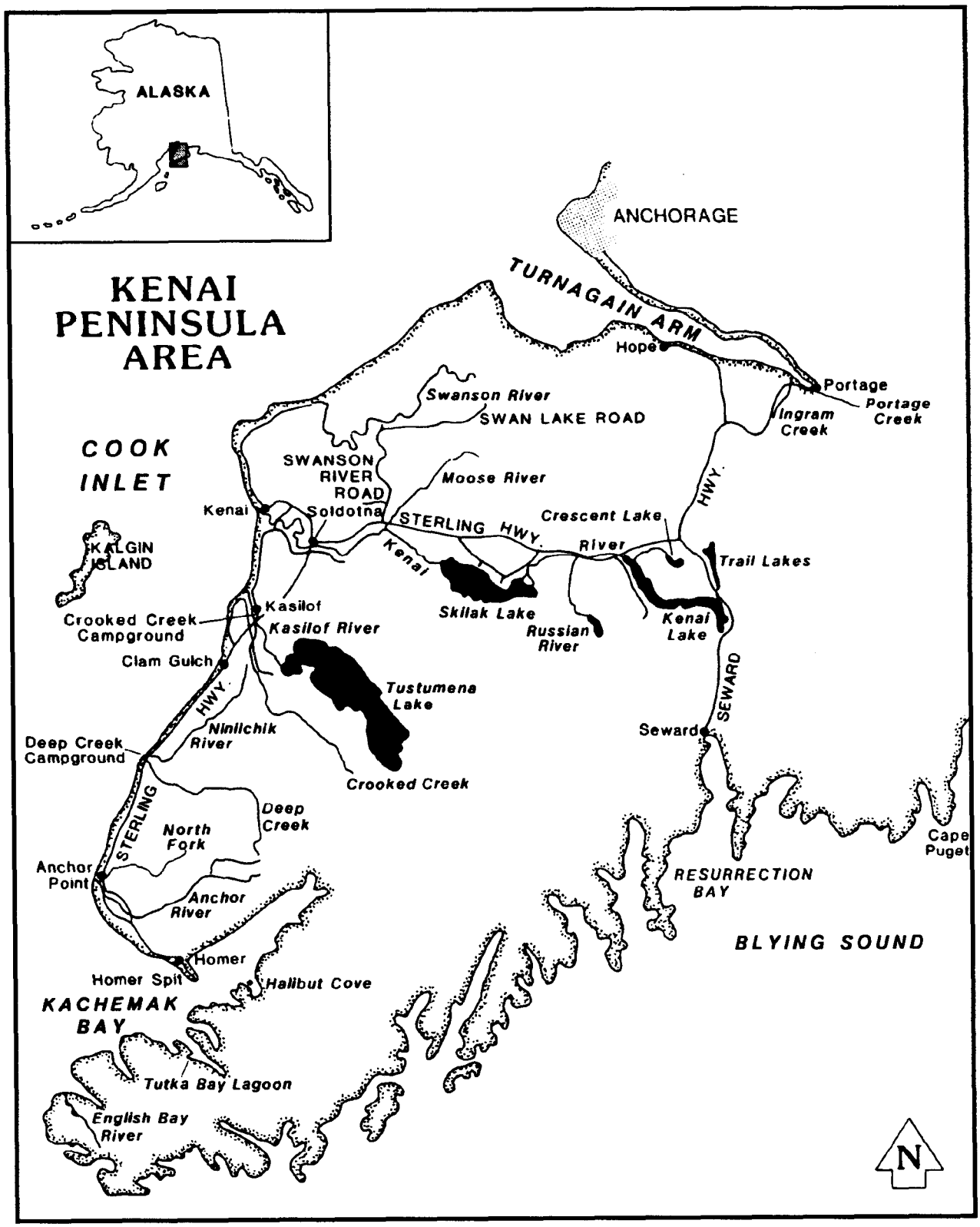

Figure 1. Map of Kenai Peninsula.

Table 1. Historical catch and harvest data from the Anchor River Dolly Varden sport fishery, 1977-1992.

Year	Creel Survey[a]		Statewide Harvest Survey[b]	
	Catch	Harvest	Catch	Harvest
1977				9,222
1978				17,357
1979				21,364
1980				10,948
1981				15,271
1982				10,375
1983				17,277
1984				5,560
1985				7,720
1986				3,910
1987	9,414	2,653		2,735
1988	11,992	2,915		2,746
1989	5,605	1,615		1,476
1990	5,391	2,124[c]	11,441	2,821
1991	5,995	1,520[d]	14,433	1,409
1992			18,303	2,532

[a] Larson et al. 1988; Larson and Balland 1989; Larson 1990-1992.

[b] Mills 1979-1993.

[c] Fishing for Dolly Varden was closed by emergency order after 7 August 1990.

[d] The daily Dolly Varden bag limit was reduced from five to two beginning in 1991.

The specific research objectives for 1992 were to:

1. census the immigration of Dolly Varden through a weir on the Anchor River during the period 1 July to 7 October;

2. estimate the length frequency of immigrating Dolly Varden at the weir by weekly intervals during the period 1 July to 15 August;

3. estimate the sex ratio, relative maturity, percent spawners, and age composition of immigrant Dolly Varden at the weir by biweekly periods during 1 July through 15 August;

4. estimate the sex ratio, relative maturity, percent spawners, and age composition of Dolly Varden harvested downstream of the weir in the Anchor River sport fishery by biweekly periods during 1 July through 15 August; and

5. census the immigration of steelhead through a weir on the Anchor River during the period 1 July to 7 October.

This is the seventh year of a long-term study of lower Kenai Peninsula Dolly Varden populations. This study provides information necessary to manage the Dolly Varden spawning stock. The acquisition of basic Anchor River and non-Anchor River population data such as a total census, length and age composition, relative maturity, and exploitation and contribution rates to the fishery will provide the means to estimate key population parameters necessary for estimating maximum sustained yield (MSY). Since this fishery is complicated by concurrent fisheries for other species, it is also necessary to acquire specific fisheries information on all species so that additional regulatory measures (if necessary) can be effectively implemented.

This report includes historical data pertaining to Dolly Varden of the Anchor River that have been compiled and analyzed from the following sources: Allin (1954, 1957), Balland (1985, 1986), Nelson et al. (1987), Larson et al. (1988), Larson and Balland (1989), Larson (1990-1992), Wallis and Balland (1981-1984) and Wallis and Hammarstrom (1979-1982). Harvest and effort estimates have been reported by Mills (1979-1992).

METHODS

Study Design

A floating weir was installed in the Anchor River at the upstream limit of tidal influence to assess the immigration and emigration of all Dolly Varden and steelhead over 200 mm in fork length between 4 July and 7 October. A random sample of immigrant Dolly Varden was collected at the weir and assessed for length, sex, age, and maturity during biweekly periods from 4 July through 15 August. Gonad development as described by Blackett (1968) was used to determine the relative maturity of female Dolly Varden collected at the weir. A random sample of harvested Dolly Varden was examined from the sport fishery and sampled for length, age, sex, and relative maturity during biweekly periods from 1 July through 1 September. Males and females were assumed to

have the same proportions in the different maturity categories for both weir and sport harvest samples.

Anchor River Weir

A weir was installed approximately 1.5 km upstream from the saltwater terminus of the Anchor River (Figure 2). The weir structure was constructed nearly entirely of floating weir panels, with rigid panels connecting the floating panels to the embankments. The rigid panel pickets were 1.25 cm diameter solid aluminum rods placed in an aluminum channel framework having a 1.25 cm gap between pickets. Channel frames were 3.6 m long by 1.05 m high. The aluminum frames rested against 1.05 m high vertical weir panels at the outer extremities of the floating weir panels and sandbag abutments along the shoreline. The floating panel pickets were 2.5 cm diameter hollow PVC tubing, capped at each end to provide buoyancy, having a 1.5 cm gap between pickets. Each panel, 4.5 m long, was anchored at one end to a cable and railroad track hinge system laid perpendicular to the stream flow and along the stream bottom. A resistance board fastened to the downstream end of each panel provided the necessary lift to the panels as river water depth varied. Traps were installed to capture both upstream and downstream migrating fish. The weir prevented passage of fish approximately 200 mm and larger.

Most fish passing through the upstream and downstream traps were counted by species and examined for tags and evidence of angler hook wounds. Dolly Varden were tagged over a 4-year period from 1986-1989. Tagging occurred on the Anchor River (1986-1989), Deep Creek (1987), and Ninilchik River (1987-1988). Dolly Varden that were difficult to handle were anesthetized in a CO_2 water bath prior to being measured, otherwise a tagging cradle was used (Hammarstrom and Larson 1985). Fish sampled from the upstream trap were chosen by randomly selecting a trap load and sampling all fish from that trap load, whereas all fish in the downstream trap were sampled.

To achieve the desired precision for estimates, approximately 8% of the immigrating Dolly Varden was sampled for length (nearest millimeter fork length). Approximately 4% of the Dolly Varden immigration was sampled for age, sex, relative maturity, and weight. These fish were sacrificed, weighed, and measured to the nearest millimeter fork length; otoliths were removed for age determination (Williams and Bedford 1973); and relative maturity was recorded for females. Each female Dolly Varden sampled for relative maturity was given a maturity index code of 1 to 5 according to the following criteria (Blackett 1968): (1) immature female with egg diameter less than 0.9 mm; (2) mature female with egg diameter greater than 1.75 mm; (3) completely mature female, eggs easily stripped; (4) completely spawned female; and, (5) immature female but showing development, egg diameter greater than 0.9 mm and less than 1.75 mm. Dolly Varden given maturity index codes of 2, 3, or 4 were categorized as spawners, those with index code 1 were categorized as nonspawners, and those with index code 5 were potential spawners. Males and females were assumed to have the same proportions in the different maturity categories.

Biological sampling was not scheduled to include the Dolly Varden immigration after 15 August because this segment of the immigration was presumed to consist mostly of nonspawners in numbers inadequate to satisfy sampling requirements over biweekly periods. However, by mid-September, Dolly Varden exhibiting post spawner attributes, e.g. spawning coloration but without adequate girth to spawn, were observed passing upstream through the weir

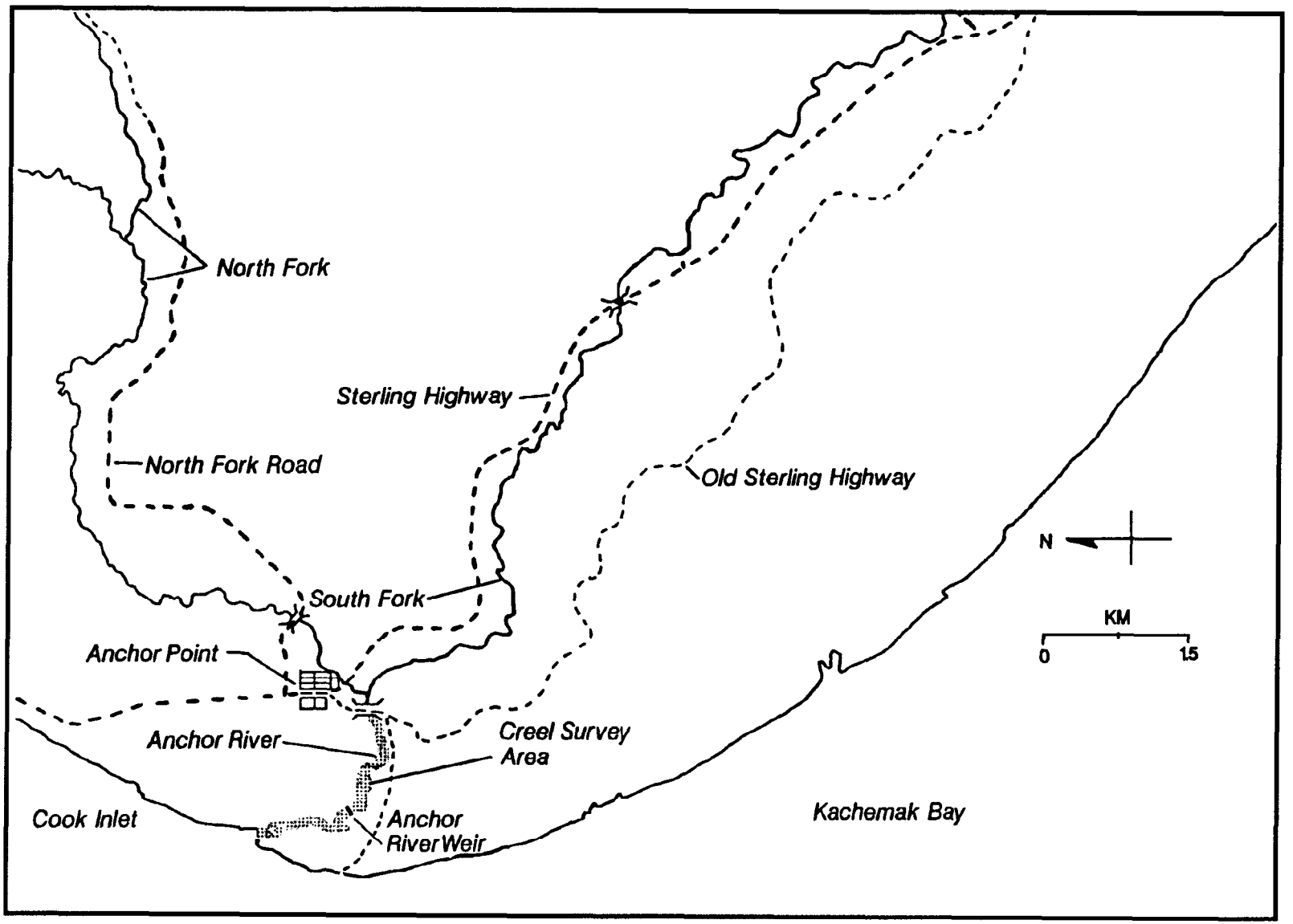

Figure 2. Map of the Anchor River.

structure. Therefore, a total of 78 Dolly Varden were sampled for length and of these, 23 fish were sacrificed for age and sexual maturity information.

Mortalities deposited on the upstream side of the weir face and in the downstream trap were sampled for age (removal of otoliths), sex, relative maturity, and length (nearest millimeter fork length). Mortalities were also examined for injuries. The purpose of sampling mortalities was to assess the different types of injuries which may be affecting Dolly Varden of various age, length and sexual maturity, in particular hook wounds. These observations are subjective in nature and do not necessarily constitute the cause of death but could have management implications depending on frequency.

Approximately 10% of the steelhead immigration was sampled for length and age. Three scales were extracted from the preferred area (three scale rows dorsal to the lateral line and directly below the posterior end of the dorsal fin) for age analysis.

Sport Fishery

Estimates of harvest of Dolly Varden and effort at the Anchor River were provided through the post-season statewide harvest survey (Mills 1993) because inseason creel survey interviews of the Anchor River recreational fishery were not conducted during 1992. These two independent estimates of harvest have not varied substantially in recent years (Table 1) and an inseason estimate was not considered necessary to manage the sport fishery. Estimates of catch from the creel survey were always substantially lower than those from the statewide harvest survey.

To obtain a maturity index of the harvest, biological samples were collected from the sport fishery from July through September by weir personnel as time was available. Time for sampling the sport harvest was limited, so weir personnel obtained as many samples as possible in the available time. The harvest was sampled at various times of the day. Fork length to the nearest millimeter was recorded, otoliths were removed for age determination, and sex and relative maturity were recorded for ungutted fish. Fish were also examined for injuries.

Stock Structure and Dynamic Rates

The proportions of fish in each age and sexual maturity component from 1989-1992, and their respective variances, were estimated as simple proportions (Cochran 1977, pages 50-52). Sexual maturity was categorized by maturity index codes 1-5, and by spawners (codes 2-4 combined), nonspawners (code 1), and potential spawners (code 5). The inclusion of 1987 and 1988 data was based on 1989 maturity index and length frequency data (Larson 1990). Based on 1989 length frequency data, Dolly Varden less than 300 mm fork length were considered nonspawners; fish 300 mm-349 mm, potential spawners; and fish greater than 349 mm, spawners. Males and females were assumed to have the same proportions in the different maturity categories.

The number of Dolly Varden (sexes combined) by sexual maturity or age component was estimated for biweekly time periods by:

$$\hat{N}_{i1} = \hat{P}_{i1}\hat{N}_i \qquad (1)$$

where:

$\hat{N}_{il}$ = estimated number of fish in length range or age class l during period i;

$\hat{P}_{il}$ = proportion of fish in length range or age l during period i; and,

N_i = weir count during period i.

The variance was estimated as:

$$V(\hat{N}_{il}) = N_i^2 V(\hat{P}_{il}). \quad (2)$$

The length frequency of immigrating Dolly Varden changes over time (Larson et al. 1988), therefore the estimated population of each sexual maturity component was stratified temporally in three, 2-week periods from July through mid-August. The time frame, July through mid-August, encompasses most of the Dolly Varden immigration and was common to all 6 years of weir operation.

Annual survival to the weir and instantaneous dynamic rates were computed from estimates of numbers by age of the immigration through the weir in 1991 (Larson 1992) and 1992. (Dynamic rates for 1988-1991 were first presented in Larson 1992.) These data were used to compute estimates of annual survival (S) from 1991 to 1992 by age (Ricker 1975):

$$S = \frac{N_{[t+1,a+1]}}{N_{[t,a]}}, \quad (3)$$

where:

N = immigration through the weir;
t = year; and,
a = age.

Annual mortality (A) was computed by subtraction:

$$A = 1 - S. \quad (4)$$

Annual fishing mortality or exploitation (E) was defined as mortality due to fishing which occurs in the Anchor River downstream of the weir. Currently, nearly all of the harvest occurs downstream of the weir. Exploitation was computed from estimates of harvest (C) and immigration (N) by age:

$$E = \frac{C_{[t,a]}}{C_{[t,a]} + N_{[t,a]}}. \quad (5)$$

The instantaneous rate of total mortality (Z) was computed as (Ricker 1975):

$$Z = -\ln(S). \quad (6)$$

Instantaneous annual fishing mortality (F) was computed from the Baranof catch equations:

$$C = N * (F / Z) * (1 - e^{-Z}), \quad (7)$$

$$F = \frac{C}{1 - e^{-Z}} * (Z / N). \quad (8)$$

Instantaneous natural mortality (M) was computed by subtraction:

$$M = Z - F. \quad (9)$$

RESULTS

The Anchor River weir was in continuous operation from 4 July to 1 October 1992. The weir was removed from the river on 1 October, 7 days earlier than scheduled, when river ice submerged several of the floating panels and threatened to damage the weir structure. River water levels varied considerably throughout the duration of the weir operation, however, the weir structure was considered "fish tight" during its entire operation. The replacement of many rigid weir panels used during 1991 with floating was considered a major improvement to the overall weir structure during 1992 and allowed for an accurate assessment of fish even during high water periods. Depth readings were recorded daily at 2200 hours from 3 July through 30 September and temperature readings were recorded continually with a thermograph from 3 July through 14 September. Water depth and temperature recorded at the upstream trap location (Appendix A1) varied from 21 cm to 55 cm and -0.5°C to 18.1°C, respectively. Daily water temperature readings varied from 0.8°C to 5.4°C within a 24-hour period. In comparison, the water depth was less and water temperature comparable to 1991, which was cooler than most previous years (Nelson et al. 1987, Larson et al. 1988, Larson and Balland 1989, Larson 1990-1992).

Inriver Abundance of Dolly Varden

A total of 10,051 Dolly Varden approximately 200 mm or greater in length were counted passing upstream of the Anchor River weir from 4 July to 1 October (Appendix A2). The peak of the immigration occurred on 18 July (Figure 3), with 50% of the run having passed the weir by 23 July (Figure 4).

Age, Length, Sexual Maturity, and Sex Composition of Dolly Varden

Dolly Varden immigrating through the weir and sampled in the sport fishery ranged in age from 2 to 9 years (Table 2). The age composition between weir and sport fishery samples was significantly different ($\chi^2 = 15.12$, df = 4, $P < 0.005$). Fish less than age 5 were more prevalent (49%) in weir samples than in the sport harvest (39%). This continues to support the hypothesis that anglers are size-selective when harvesting fish (Larson 1990-1992). Anglers also harvested a greater proportion of females than males over the age of 5 (Figure 5) and these females tended to be spawners (Table 3).

Immigrating male Dolly Varden were predominantly age 4 and females were predominantly age 5 (Figure 5). Few fish were older than age 6 and the

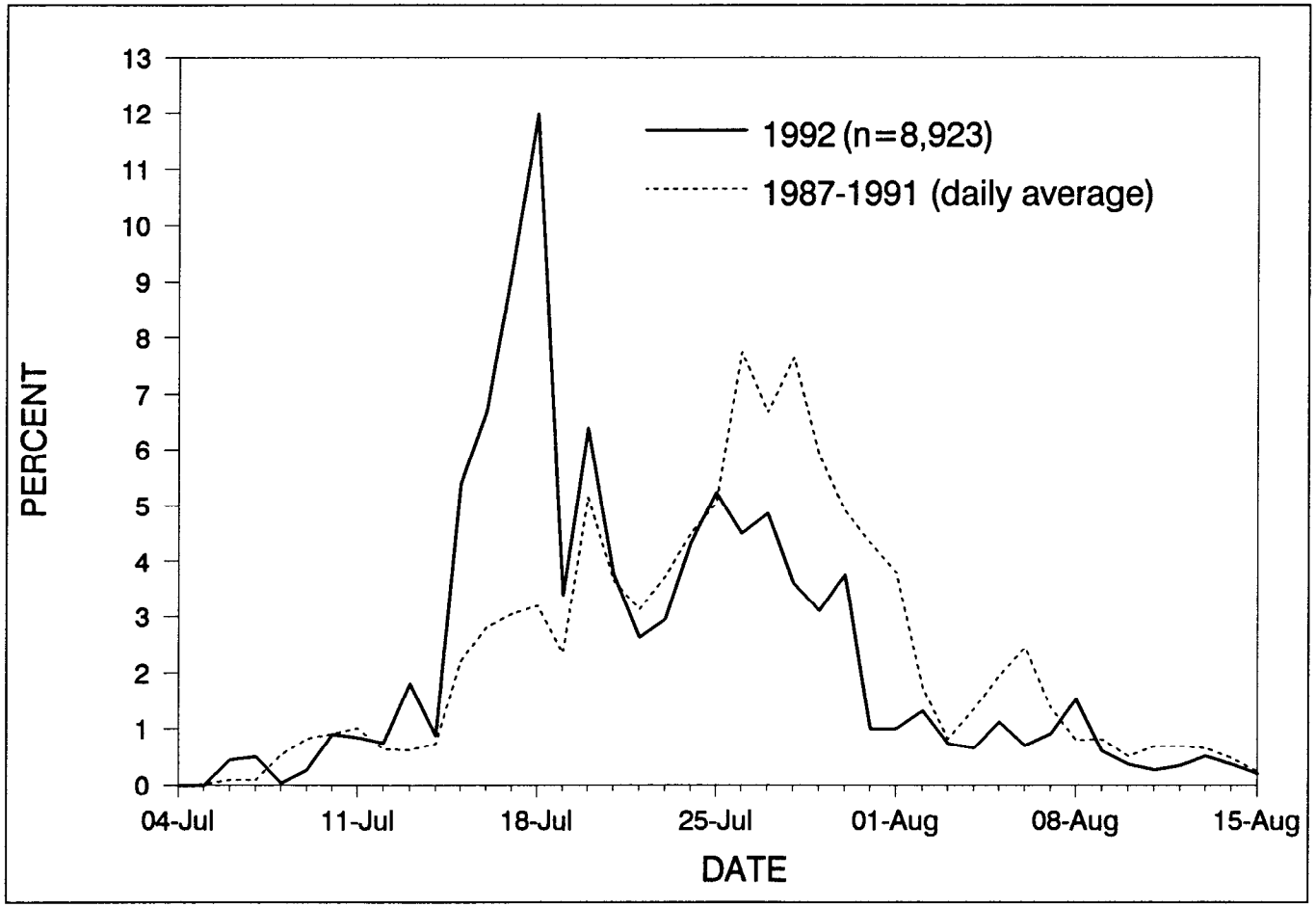

Figure 3. Daily run timing of Dolly Varden entering the Anchor River, 4 July-15 August. Fish were counted while passing upstream through the Anchor River weir, 1987-1992.

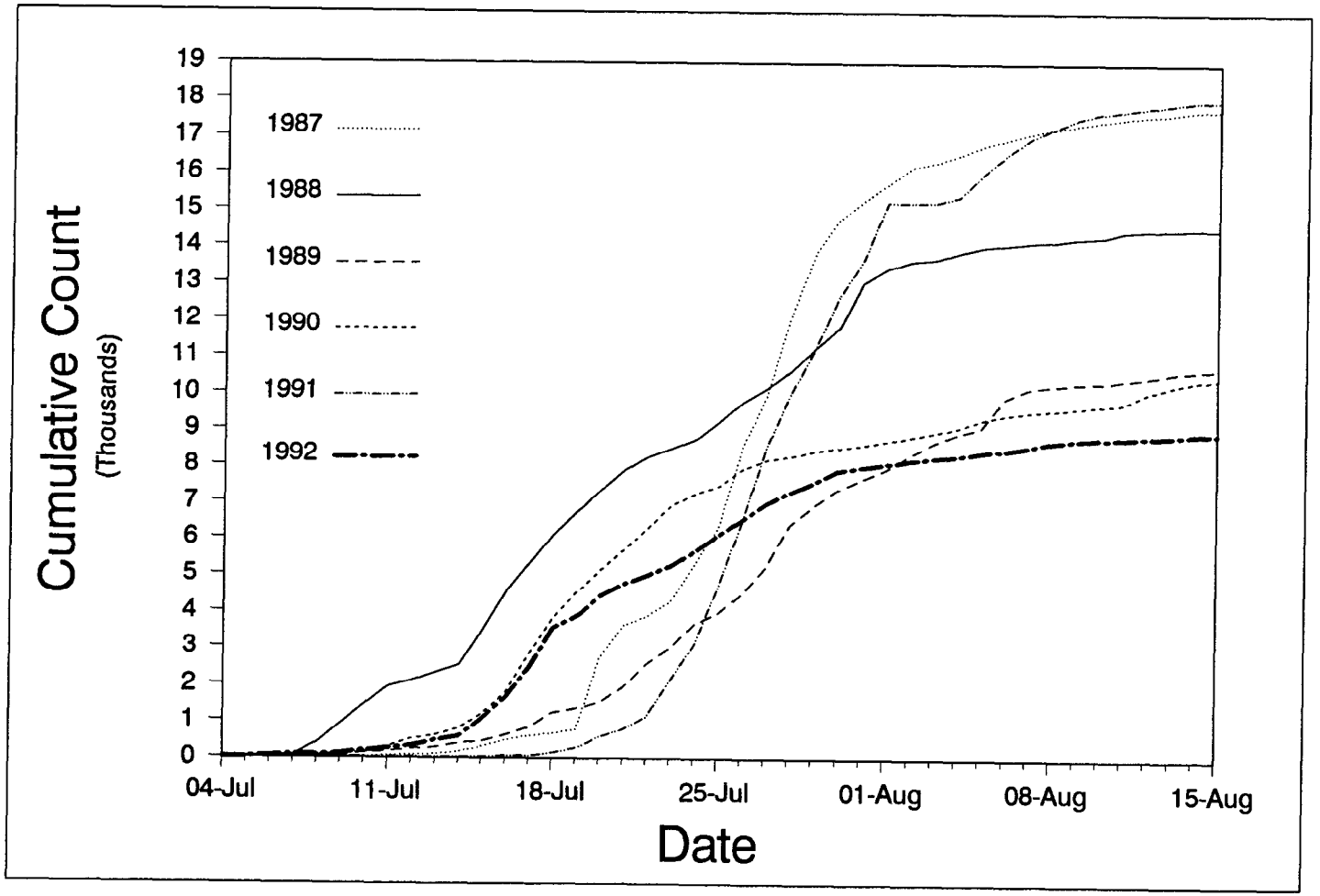

Figure 4. Cumulative run timing of Dolly Varden entering the Anchor River, 4 July-15 August. Fish were counted while passing upstream through the Anchor River weir, 1987-1992.

Table 2. Age and sex compositions of Dolly Varden collected at the weir site and in the sport harvest on the Anchor River during 1992.

	Age Group								
Component	2	3	4	5	6	7	8	9	Total
Weir Samples (Upstream Trap)									
Male									
Percent	0.6	21.1	29.2	28.0	16.8	2.5	1.9	0.0	42.5
Sample Size	1	34	47	45	27	4	3		161
Female									
Percent	0.0	15.1	32.1	34.4	14.2	3.7	0.5	0.0	57.5
Sample Size		33	70	75	31	8	1		218
Sexes Combined									
Percent	0.3	17.7	30.9	31.7	15.3	3.2	1.1	0.0	100.0
Sample Size	1	67	117	120	58	12	4		379
Sport Harvest									
Male									
Percent	0.0	8.8	47.1	27.9	10.3	1.5	1.5	2.9	53.1
Sample Size	0	6	32	19	7	1	1	2	68
Female									
Percent	0.0	1.7	21.7	45.0	26.7	1.7	1.7	1.7	46.9
Sample Size	0	1	13	27	16	1	1	1	60
Sexes Combined[a]									
Percent	0.0	4.9	34.3	35.0	21.0	1.4	1.4	2.1	100.0
Sample Size	0	7	49	50	30	2	2	3	143

[a] The combined sex category contains additional samples than the sum of the individual male and female categories. This is due to some sport harvest biological samples being obtained from anglers after they had already extracted the gonads, i.e., age could be determined but not sex.

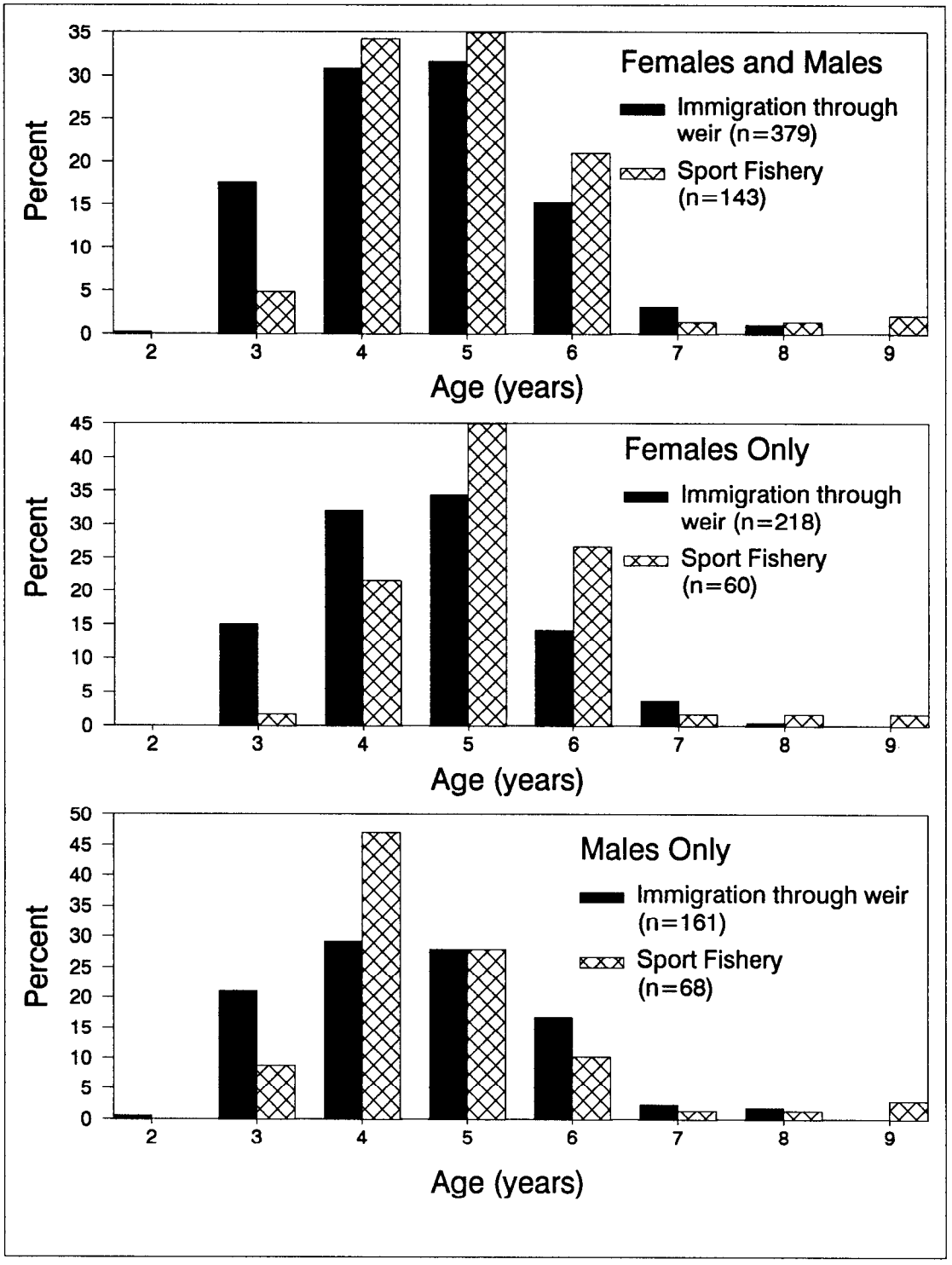

Figure 5. Age and sex composition of Dolly Varden sampled at the Anchor River weir site and in the sport fishery, 1992.

Table 3. Relative maturity of Dolly Varden sampled at the Anchor River weir and in the sport fishery by period, 1992.

	Female Maturity Index[a]																				
	1				2				3				4				5				
Period	Sample Size	%	Mean Length (mm)	Est. Total Fish	Sample Size	%	Mean Length (mm)	Est. Total Fish	Sample Size	%	Mean Length (mm)	Est. Total Fish	Sample Size	%	Mean Length (mm)	Est. Total Fish	Sample Size	%	Mean Length (mm)	Est. Total Fish	Total Fish Sampled
Weir Samples																					
7/4-18	5	7	262	74	45	63	380	669	0	0			0	0			22	31	311	327	72
7/19-31	14	21	232	1,463	37	56	400	3,868	0	0			0	0			15	23	307	1,568	66
8/1-15	38	66	240	624	10	17	338	164	0	0			0	0			10	17	296	164	58
9/16-30	0	0		0	0	0			2	13	392	46	6	38	378	139	8	50	321	185	16
7/4-9/30	57	27	240	2,161	92	43	384	4,701	2	1	392	46	6	3	378	139	55	26	309	2,244	212
Sport Harvest																					
7/1-18	1	7	290		6	40	362		0				0				8	53	367		15
7/19-31	2	7	283		20	67	433		0				0				8	27	360		30
8/-9/1	2	20	302		5	50	421		0				0				3	30	361		10
7/1-9/1	5	9	292		31	56	417		0				0				19	35	363		55

[a] Maturity index: 1 = immature female with egg diameter less than 0.9 mm; 2 = mature female with egg diameter greater than 1.75 mm; 3 = completely mature female (eggs easily stripped); 4 = completely spawned female; and 5 = immature female but shows development, egg diameter greater than 0.9 mm and less than 1.75 mm.

combined year-classes from 7 through 9 accounted for less than 10% of the run. These results are consistent with those observed in 1990 and 1991 (Larson 1991-1992) and suggest a low frequency of repeat spawning due to high natural or fishing mortality.

The age distribution of immigrating Dolly Varden changed significantly (χ^2 = 75.054, df = 6, P < 0.001) by age class over biweekly periods. The proportion of younger fish increased from 4 July through 15 August and then decreased by late September. Of 384 fish sampled at the weir, 57% were females and of 135 fish sampled in the sport harvest, 45% were females. These ratios did not change significantly (χ^2 = 0.159, df = 2, P > 0.900) over time when compared in biweekly periods (Table 4). These results are contradictory to 1990 (Larson 1991) but similar to 1991 (Larson 1992) findings.

One-way analysis of variance (Snedecor and Cochran 1967) was used to test the null hypothesis that there was no change in mean length of fish by age class across biweekly periods at the weir. The mean length changed significantly for age-4 (F = 17.7, df = 3, 113, P < 0.001), age-5 (F = 13.0, df = 3, 116, P < 0.001) and age-6 (F = 3.6, df = 3, 54, P < 0.02) fish. Generally, the mean length decreased within each of these age classes from 4 July through 15 August and then increased during late September. The combination of an increase in proportion of younger fish from 4 July through 15 August and a decrease in size within this time period resulted in an overall change in mean length of fish across weeks at the weir (Figure 6). The mean length decreased each week from the first week through the third week, increased slightly during the fourth week, decreased from the fourth week through the sixth week and then increased again during the twelfth and thirteenth weeks. These results are consistent with those observed from 1989 through 1991 (Larson 1990-1992).

Dolly Varden harvested in the sport fishery averaged 30 mm-60 mm larger than those sampled at the weir (Table 5 and Figure 7) in all age classes except age 7, thus indicating a tendency by anglers to harvest larger fish. The sample size of sport harvested spawners and nonspawners was insufficient for statistical length comparisons between sport harvested fish and those sampled at the weir.

Estimates, based on female maturity index codes, of the Dolly Varden immigration through the weir from 4 July through 15 August indicate that about 47% were spawners, 26% potential spawners, and 27% nonspawners (Table 3, Figure 8, and Appendix A3). There was a significant difference (χ^2 = 11.59, df = 2, P < 0.005) in the total percentage of each maturity index category observed between weir samples (n = 212) and the sport harvest (n = 55) (Table 3). There were proportionately fewer nonspawners in the sport harvest than the weir samples. This was comparable to 1991 results. An estimated 88% of the sport harvest was over 300 mm in fork length (Table 6), and generally, fish greater than 300 mm sampled from the immigration through the weir are potential spawners (Table 3 and Larson 1990-1992).

The proportion of immigrating Dolly Varden nonspawners (female maturity index code 1) and spawners (female maturity index code 2) changed significantly (χ^2 = 53.4, df = 2, P < 0.005) over time (Table 3). Nonspawners increased in abundance while spawners decreased biweekly through August 15. These results are consistent with those observed in 1989 and 1990 (Larson 1990-1991).

Table 4. Estimated sex ratios of Anchor River Dolly Varden sampled biweekly from the weir site and in the sport fishery, 1992.

	7/4 - 7/18		7/19 - 7/31		8/1 - 8/16		8/16 - 9/30				
Sex	Count	%	Count	%	Count	%	Count	%	Total Count	%	Estimated Weir Population
Weir											
Male	48	40	54	45	55	45	7	30	164	43	4,371
Female	72	60	66	55	66	55	16	70	220	57	5,680
Total	120	100	120	100	121	100	23	100	384	100	10,051
Sport Fishery											
Male	18	50	40	56	16	59	0	0	74	55	
Female	18	50	32	44	11	41	0	0	61	45	
Total	36	100	72	100	27	100	0	0	135	100	

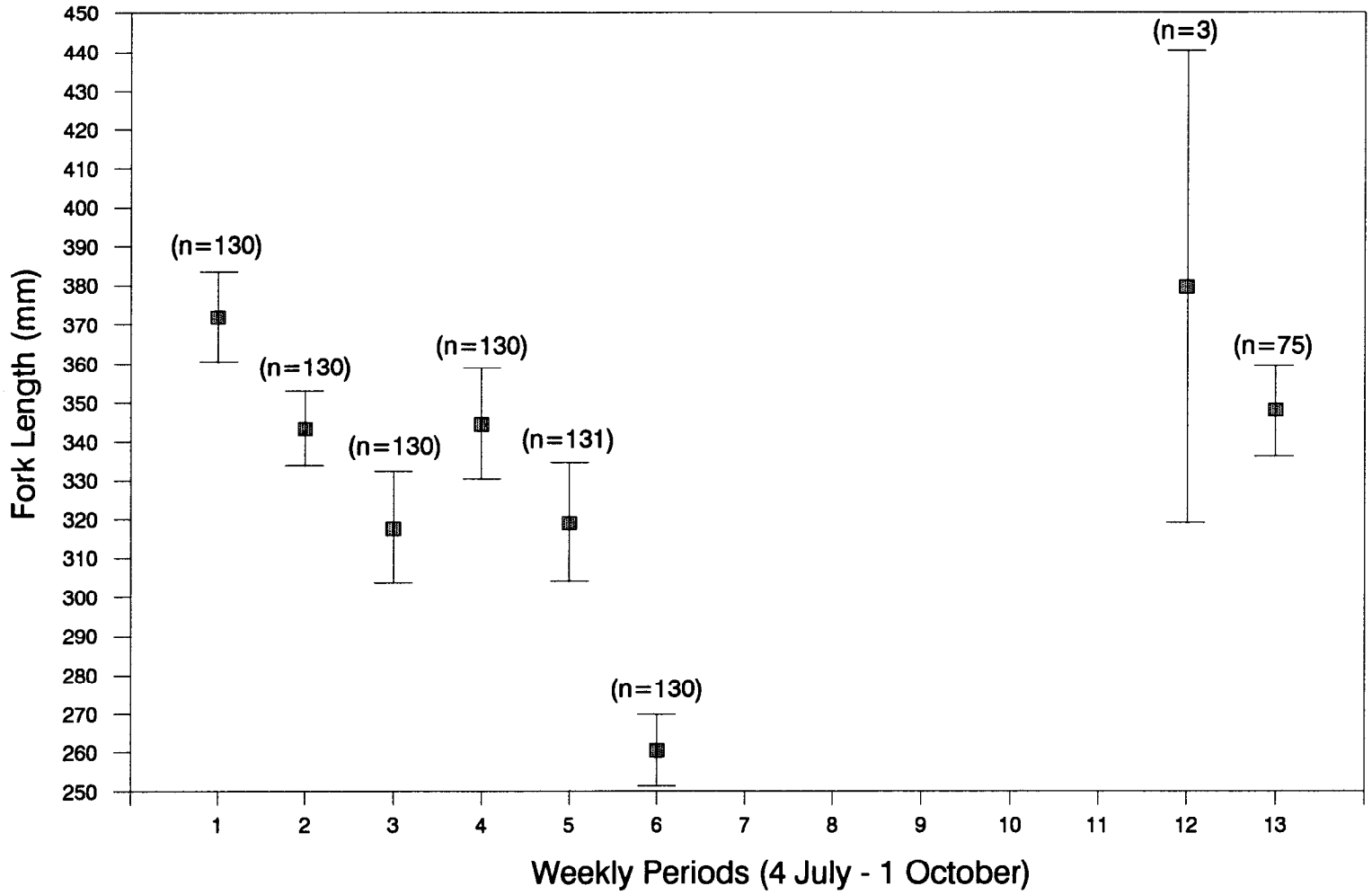

Figure 6. Mean length by weekly period with 95% confidence intervals from Dolly Varden sampled moving upstream through the Anchor River weir, 1992.

Table 5. Mean length (millimeters) by age group and female sexual maturity of Dolly Varden collected at the Anchor River weir site and in the sport fishery, 1992.

Component	Age Group 3	4	5	6	7	8	9	10
Weir Samples (Upstream Trap)								
Nonspawners[a]								
Mean Length	232	251	237					
Standard Error	6.4	7.7	17.5					
Sample Size	28	22	7					
Potential Spawners[b]								
Mean Length	287	306	308	325	330			
Standard Error	0.5	4.3	6.2	9.8				
Sample Size	2	28	18	6	1			
Spawners[c]								
Mean Length		352	374	406	441	368	426	
Standard Error		5.9	5.8	8.2	16.1			
Sample Size		18	51	24	7	1	1	
Sport Harvest								
Nonspawner[a]								
Mean Length	283	283	305					
Standard Error		32	15					
Sample Size	1	2	2					
Potential Spawners[b]								
Mean Length		362	357	356	487			
Standard Error		15.5	8	8				
Sample Size		5	6	6	1			
Spawners[c]								
Mean Length		386	401	438	540	440		550
Standard Error		55.5	12.6	16				
Sample Size		3	16	10	1	1		1

[a] Immature females with egg diameter less than 0.90 mm (maturity index code 1).

[b] Immature females showing development, egg diameter greater than 0.90 mm and less than 1.75 mm (maturity index code 5).

[c] Mature females with egg diameter greater than 1.75 mm, or completely mature females (eggs easily stripped), or completely spawned females (maturity index codes 2-4).

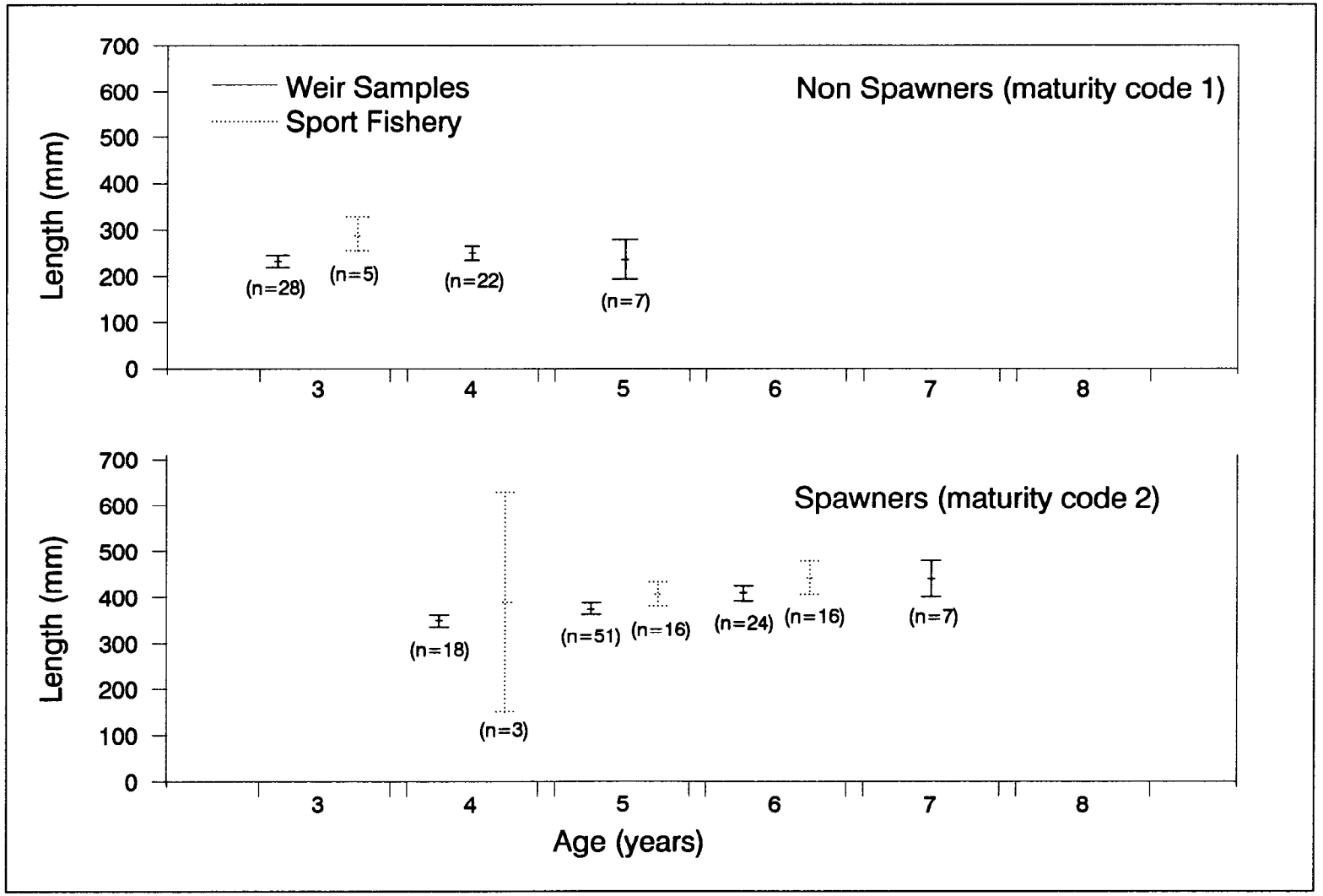

Figure 7. Mean length by age with 95% confidence intervals from nonspawner and spawner Anchor River Dolly Varden sampled at the weir and in the sport fishery, 1992.

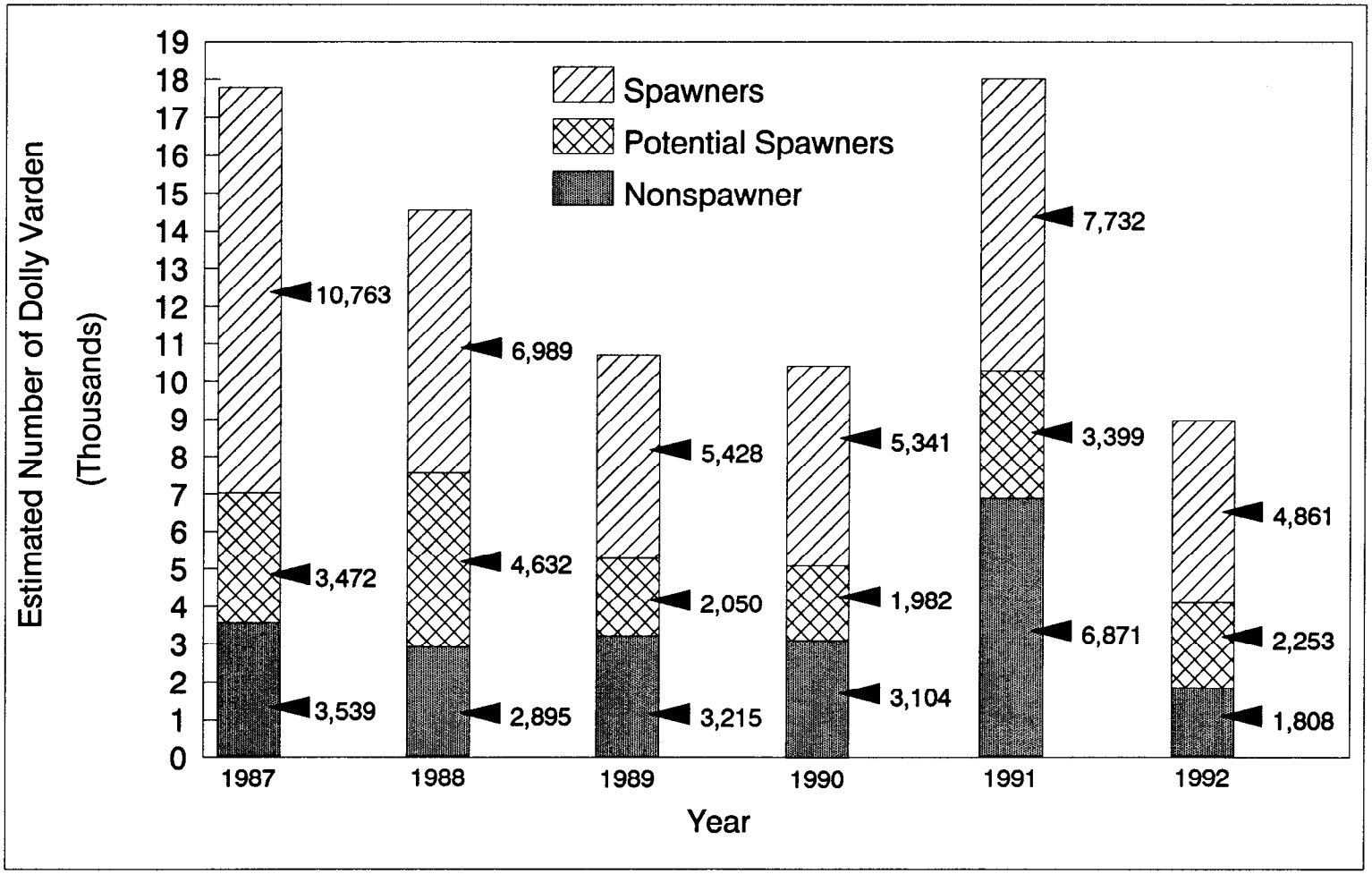

Figure 8. Estimated sexual maturity component of immigrating Dolly Varden sampled at the Anchor River weir from July through 15 August, 1987-1992.

Table 6. Number of Dolly Varden sampled from the upstream trap, sport harvest, mortalities recovered at the weir site, and downstream trap, by length range, Anchor River, 4 July-30 September 1992.

Length Range	Upstream Trap		Sport Harvest		Mortalities		Downstream Trap	
	Count	%	Count	%	Count	%	Count	%
<200	13	2	0	0	0	0	13	5
200-249	178	21	6	4	10	5	81	33
250-299	117	14	12	8	19	9	47	19
300-349	200	23	41	27	68	33	60	25
350-399	203	24	43	29	73	35	29	12
400-449	96	11	25	17	27	13	12	5
450-499	35	4	17	11	6	3	0	0
500>	17	2	6	4	3	1	0	0
Total	859	100	150	100	206	100	242	100

Estimates of the Dolly Varden immigration through the weir after 15 August apply only to the biweekly period 16-30 September (Appendix A3 and A4). A total of 23 Dolly Varden was sampled for age and sex; 16 fish were females which provided maturity index information. Most (87%) of the fish were age 4 or age 5, 38% were female post spawners (maturity index category 4) and 13% were fully mature female spawners (maturity index category 3). Although these sample sizes were inadequate for statistical comparisons, it is evident that post spawners entered the Anchor River during this time period.

The cumulative length distribution between immigrating spawners and nonspawners differed significantly at age group 4 (D_{max} = 0.91; n = 14, 22; $P < 0.001$) and age group 5 (D_{max} = 0.91; n = 46, 7; $P < 0.001$), spawners being larger than nonspawners (Table 5). These results are consistent with those observed from 1989 through 1991 (Larson 1990-1992).

Dolly Varden Emigration

A total of 505 Dolly Varden were counted moving in a downstream direction from 4 July to 1 October (Appendix A5). Biological samples were collected from 207 mortalities and 243 live Dolly Varden. The remaining 55 fish were counted and released alive downstream of the weir.

A total of 207 Dolly Varden were found dead in the downstream trap or along the upstream side of the weir face (Table 7). A subjective examination for possible causes of death revealed 73 fish (35.3%) with apparent hook wounds, 55 (26.6%) fish with net injuries, 40 (19.3%) fish with unknown injuries, 20 (9.7%) fish with predator injuries, and 19 (9.2%) fish with no apparent injuries. Injuries which resulted in lesions to the skin generally had topical evidence of a bacterial infection resembling furunculosis (a necrotic lesion which ulcerates to release lightly infectious reddish fluid).

The incidence of net injuries increased from the least prevalent injury observed in 1991 to the second most prevalent injury in 1992. Net injuries were most likely a result of commercial fishing activity in salt water, however, some net injuries may have resulted from illegal fishing activity upstream of the weir site. Most net injuries developed furunculosis-like symptoms by the time the fish died but some net marks were suspiciously fresh on several mortalities. The total number of mortalities observed at the weir (n = 207) approximately doubled from 1991 (n = 96). This increase in observed weir mortalities is in part (74%) the result of the increased incidence of net injuries (50%) and an additional 6 weeks (24%) of weir operation.

Of the 243 live Dolly Varden passing through the downstream trap from 4 July to 1 October (Table 7 and Appendix A5), the majority (58%) of these fish were less than 300 mm in fork length. When examined for injuries, 88.1% had no apparent injuries while 9.1% had apparent hook wounds. The majority (75%) of the emigration occurred after 15 August.

Tag recoveries from Dolly Varden tagged on lower peninsula streams during 1986-1989 total 1,014 (Larson 1992). There were no tags recovered during 1991 or 1992 and additional tag recoveries are unlikely.

Table 7. Injuries observed by length range from Dolly Varden sampled in the emigration through the Anchor River weir and from mortalities collected at the weir site, 1992.

Length Range	No Injuries	%	Angler Wound	%	Net Wound	%	Unknown Injuries	%	Predator Injuries	%	Total
Weir Site											
<200		0.0		0.0		0.0		0.0		0.0	0
200-249	1	0.5	4	1.9		0.0	3	1.4	2	1.0	10
250-299	3	1.4	11	5.3	2	1.0		0.0	3	1.4	19
300-349	6	2.9	30	14.5	17	8.2	12	5.8	2	1.0	67
350-399	7	3.4	18	8.7	28	13.5	12	5.8	10	4.8	75
400-449	2	1.0	7	3.4	7	3.4	10	4.8	2	1.0	28
450-499		0.0	3	1.4		0.0	2	1.0	1	0.5	6
500>		0.0		0.0	1	0.5	1	0.5		0.0	2
Total	19	9.2	73	35.3	55	26.6	40	19.3	20	9.7	207
Downstream Migration											
<200	12	4.9	1	0.4		0.0		0.0		0.0	13
200-249	75	30.9	5	2.1		0.0	1	0.4		0.0	81
250-299	45	18.5	1	0.4		0.0		0.0	1	0.4	47
300-349	50	20.6	9	3.7		0.0	1	0.4	1	0.4	61
350-399	24	9.9	4	1.6		0.0	1	0.4		0.0	29
400-449	8	3.3	2	0.8		0.0		0.0	2	0.8	12
450-499		0.0		0.0		0.0		0.0		0.0	0
500>		0.0		0.0		0.0		0.0		0.0	0
Total	214	88.1	22	9.1	0	0.0	3	1.2	4	1.6	243

Stock Structure and Dynamic Rates

The estimated spawner component of immigrating Dolly Varden sampled at the Anchor River weir from 4 July through 15 August decreased each year from 1987 through 1990, increased during 1991 and then decreased to near 1990 levels during 1992 (Table 8 and Figure 8). The combined potential spawner and nonspawner components have ranged from approximately 4,000 to 10,300 fish annually during the period 1987-1992 (Figure 8). The nonspawners are considered to be of mixed origin (Armstrong 1965), and therefore, variations in nonspawner abundance are not necessarily reflective of the Anchor River stock status.

Estimates of annual survival through age 5 were generally greater than one (Table 9). Fish younger than age 5 were incompletely recruited to the spawning population (Table 5 and Larson 1992). The twelve estimates of annual survival for ages 6-8 were all less than one and show a strong decreasing trend as fish age from age 6 to age 8. Based on maturity sampling, these age classes are comprised virtually entirely of spawners and should annually return to spawn. These estimates seem a realistic expression of that phenomenon. While age 9 and older fish should fit the same pattern as that described for age 6-8 fish, annual survival for these age classes varies widely from 0 to 1.5 and is likely attributable to rare event sampling; these age classes are found in only trace levels (less than 1%) (Table 9).

Exploitation by the sport fishery (E) (Table 10) indicates that, in 1992, anglers harvested fish of spawning age, primarily age 4 and older.

Since the only values of S that were within realistic estimates were those for ages 5-9, these are the only instantaneous rates that have meaning. The instantaneous rates of total mortality (Z) were positive and increasing after age 4 (Table 11) during 1992. These results are inconsistent with the previous 2 years where total mortality was negative for age 4-5. This may indicate a decrease in the Dolly Varden recruitment at age 5 during 1992 that was evident in 1990 and 1991.

Although no trends were evident in instantaneous annual fishing mortality (F) downstream of the weir (Table 11), values in the ages 3-4, 5-6 and 8-9 categories were the highest recorded for these age groups.

Instantaneous natural mortality (M) (Table 11) was approximately an order of magnitude higher than the values of F for ages 5 through 9. This indicates that the number of deaths due to harvest in the sport fishery was much lower than from natural causes. These results are consistent with previous years and support the literature which indicates mortality due to spawning is high.

Steelhead Immigration

A total of 1,261 steelhead trout were counted passing upstream of the Anchor River weir from 4 July to 1 October 1992 (Appendix A2). The peak of this immigration occurred from mid to late September, with 50% of the run having passed the weir by 14 September. Based on historical run timing (Allin 1954, 1957; Larson and Balland 1989; Larson 1990), an additional 10% to 20% of the total steelhead immigration may occur after 1 October, therefore, the total estimated return of adult steelhead to the Anchor River during 1992 was approximately 1,400 to 1,600 fish.

Table 8. Estimated sexual maturity of Dolly Varden sampled at the Anchor River weir from 4 July through 15 August, 1987-1992.[a]

Year	Period	Weir Cnt	Nonspawners			Potential Spawners			Spawners		
			n	%	$\hat{N}$	*n*	%	$\hat{N}$	*n*	%	$\hat{N}$
1987	July 4-17	596	17	3.8	23	57	12.9	77	369	83.3	496
	July 18-31	14,688	215	17.3	2,534	237	19.0	2,794	794	63.7	9,360
	Aug 1-15	2,490	431	39.4	982	264	24.2	601	398	36.4	907
	Total	17,774	663	23.8	3,539	558	20.1	3,472	1,561	56.1	10,763
1988	July 4-17	5,323	105	7.8	417	431	32.2	1,712	804	60.0	3,194
	July 18-31	7,713	337	29.3	2,258	403	35.0	2,701	411	35.7	2,754
	Aug 1-15	1,480	8	14.8	219	8	14.8	219	38	70.4	1,041
	Total	14,516	450	17.7	2,895	842	33.1	4,632	1,253	49.2	6,989
1989	July 5-18	1,229	3	4.5	56	21	31.8	391	42	63.6	782
	July 19-31	6,429	50	32.9	2,115	22	14.5	931	80	52.6	3,384
	Aug 1-15	3,034	43	34.4	1,044	30	24.0	728	52	41.6	1,262
	Total	10,692	96	28.0	3,215	73	21.3	2,050	174	50.7	5,428
1990	July 2-15	1,201	12	15.8	190	15	19.7	237	49	64.5	774
	July 16-31	7,418	16	23.9	1,771	12	17.9	1,329	39	58.2	4,318
	Aug 1-15	1,808	55	63.2	1,143	20	23.0	416	12	13.8	249
	Total	10,427	83	36.1	3,104	47	20.4	1,982	100	43.5	5,341
1991	July 2-18	141	3	37.5	53	1	12.5	18	4	50.0	71
	July 19-31	13,531	24	40.0	5,412	12	20.0	2,706	24	40.0	5,412
	Aug 1-15	4,330	25	32.5	1,406	12	15.6	675	40	51.9	2,249
	Total	18,002	52	35.9	6,871	25	17.2	3,399	68	46.9	7,732
1992	July 4-18	3,547	5	6.9	246	22	30.6	1,084	45	62.5	2,217
	July 19-31	4,423	14	21.2	938	15	22.7	1,005	37	56.1	2,480
	Aug 1-15	953	38	65.5	624	10	17.2	164	10	17.2	164
	Total	8,923	57	29.1	1,808	47	24.0	2,253	92	46.9	4,861

[a] Sexual maturity was based on length for 1987 and 1988 (nonspawners: <300 mm; potential spawners: 300 mm-349 mm; spawners: >349 mm) and on gonad examination for 1989-1992.

Table 9. Anchor River Dolly Varden estimates by age of percent composition, weir counts, annual survival and annual mortality from 1 July through 15 August, 1988-1992.[a]

Year	n	Age 2	3	4	5	6	7	8	9	10+	Total
Percent											
1988	622	0.4	5.8	23.1	48.5	16.3	4.7	0.5	0.7	0.0	100.0
1989	557	0.7	7.0	23.3	25.1	32.9	8.7	2.2	0.1	0.0	100.0
1990	366	0.4	18.8	24.7	32.7	15.3	7.4	0.2	0.2	0.2	100.0
1991	240	0.9	9.2	34.8	34.6	12.1	5.8	2.3	0.2	0.0	100.0
1992	380	0.1	14.9	26.6	29.6	20.3	5.9	2.0	0.6	0.0	100.0
Weir Count											
1988	622	58	842	3,353	7,040	2,366	682	73	102	0	14,516
1989	557	71	750	2,492	2,681	3,520	933	231	14	0	10,692
1990	366	38	1,961	2,580	3,409	1,595	769	25	25	21	10,427
1991	240	164	1,663	6,262	6,229	2,185	1,040	423	36	0	18,002
1992	380	8	1,387	2,474	2,751	1,882	552	182	57	0	9,293

	Age 2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
Annual Survival								
1988-1989	12.931	2.960	0.800	0.500	0.394	0.339	0.192	0.000
1989-1990	27.620	3.440	1.368	0.595	0.218	0.027	0.108	1.500
1990-1991	43.763	3.193	2.414	0.641	0.652	0.550	1.440	0.000
1991-1992	8.457	1.488	0.439	0.302	0.253	0.175	0.135	0.000
Annual Mortality								
1988-1989	-11.93	-1.960	0.200	0.500	0.606	0.661	0.808	1.000
1989-1990	-26.62	-2.440	-0.368	0.405	0.782	0.973	0.892	-0.500
1990-1991	-42.76	-2.193	-1.414	0.359	0.348	0.450	-0.440	1.000
1991-1992	-7.46	-0.488	0.561	0.698	0.747	0.825	0.865	1.000

[a] Age composition based on fish mortalities collected on the weir face (1988) and random sampling schedules (1989-1992).

Table 10. Anchor River sport harvest estimates of percent composition, harvest and annual fishing mortality, by age, downstream of the fish weir, 1988-1992.

		Age									
Year	n	2	3	4	5	6	7	8	9	10+	Total
Percent by Age											
1988	224		2.7	26.3	47.7	17.8	3.6	1.4	0.5		100.0
1989	60		6.7	30.0	25.0	31.6	5.0	1.7		100.0	
1990	87		9.2	27.6	41.3	9.2	9.2	2.3	1.2		100.0
1991	188		3.7	23.4	36.2	24.5	9.6	1.6	0.5	0.5	100.0
1992	143		4.9	34.3	35	21	1.4	1.4	2.1		100.1
Estimated Harvest by Age											
1988	224	0	58	567	1,028	384	78	30	11	0	2,156
1989	60	0	71	316	263	333	53	18	0	0	1,053
1990	87	0	195	586	877	195	195	49	25	0	2,124
1991	188	0	56	356	550	372	146	24	8	0	1,520
1992	143	0	124	868	885	532	35	35	53	0	2,532
Annual Fishing Mortality (E) or Exploitation											
1988			0.065	0.145	0.127	0.140	0.102	0.293	0.096		
1989			0.086	0.113	0.089	0.086	0.053	0.072	0.000		
1990			0.091	0.185	0.205	0.109	0.203	0.661	0.505	0.000	
1991			0.033	0.054	0.081	0.146	0.123	0.054	0.174	1.000	
1992			0.082	0.260	0.244	0.220	0.060	0.163	0.483		

Table 11. Anchor River Dolly Varden instantaneous estimates of annual, fishing, and natural mortality, 1988-1992.

	Age							
Year	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
Instantaneous Annual Mortality (Z)								
1988-1989	-2.560	-1.085	0.224	0.693	0.931	1.083	1.651	
1989-1990	-3.319	-1.235	-0.313	0.519	1.521	3.620	2.224	-0.405
1990-1991	-3.779	-1.161	-0.881	0.445	0.428	0.598	-0.365	
1991-1992	-2.135	-0.397	0.823	1.197	1.376	1.743	2.004	
Instantaneous Annual Fishing Mortality (F)								
1988-1989	0.261	0.208	0.088	0.066	0.034	0.043	0.000	
1989-1990	0.343	0.396	0.300	0.093	0.108	0.195	0.275	0.000
1990-1991	0.131	0.096	0.133	0.135	0.112	0.042	0.252	
1991-1992	0.217	0.425	0.208	0.146	0.030	0.072	0.291	
Instantaneous Annual Natural Mortality (M)								
1988-1989	-2.821	-1.293	0.136	0.628	0.896	1.040	1.651	
1989-1990	-3.662	-1.631	-0.613	0.426	1.413	3.425	1.948	-0.405
1990-1991	-3.910	-1.257	-1.014	0.309	0.315	0.556	-0.617	
1991-1992	-2.352	-0.823	0.615	1.050	1.346	1.671	1.713	

A total of 123 steelhead provided length and age composition data (Table 12). All but one fish were determined to be first time spawners. Age group 3.2 (steelhead that had spent 3 years in fresh water and 2 years at sea) were the most prevalent age group sampled (47%). This is comparable to 1988 observations when 52% of the first time spawners were of age group 3.2 (Larson and Balland 1989).

DISCUSSION

Dolly Varden

The 1992 immigration of Anchor River Dolly Varden decreased approximately 50% from the record 1991 weir count of over 20,000 fish. The 1992 return represents the smallest return since a weir was established in 1987. The reason(s) for this population decline is not completely understood and additional studies are required.

The decrease in Dolly Varden spawners during 1992 is attributed to a low return of age-5 and age-6 fish. A larger return of age-5 and age-6 fish during 1992 was predicted based on the high number of age-4 nonspawners and age-5 spawners observed during 1991 (Larson 1992). The lack of age 5 and 6 fish during 1992 indicates that estimating future returns based on the indices of nonspawners is unreliable. Anchor River Dolly Varden nonspawners may be of mixed stock origin and their numbers, therefore, are not reflective of Anchor River recruitment. Observing a large number of nonspawners in the Anchor River during any given year does not necessarily reflect a strong return of spawners in subsequent years.

The mean length of Dolly Varden decreased as the immigration progressed from July through mid August. Based on maturity index and age data, this appears to be a function of a decreasing proportion of spawners to nonspawners over time, primarily within age classes 4-6. This phenomenon has potential management implications. If additional conservative management of the sport fishery becomes necessary, restricting the sport fishery during the beginning of the Dolly Varden immigration would offer the greatest protection to the spawning segment (fish of Anchor River origin) of the immigration. Because Dolly Varden nonspawners are believed to consist of mixed stocks, liberalization of the Dolly Varden fishery later in the immigration would have the least impact on fish of Anchor River origin.

Stock Structure and Abundance:

The appearance of post spawner Dolly Varden immigrating through the Anchor River weir was first documented in 1989. However, during 1989, the weir had washed out on several occasions prior to the observance of post spawners at the weir site. The possibility existed that these fish were Anchor River spawners that had been relocated downstream of the weir after a high water event, ultimately passing through the upstream weir trap a second time. During 1992, the weir did not wash out at any time during its operation and post spawners were not passed through the downstream trap. The post spawners observed during 1992 were first-time immigrants. It is likely these fish overwinter in the Anchor River.

Table 12. Length and age composition of first time and repeat steelhead/rainbow trout spawners, Anchor River, 1992.

		Length (mm)		
Age Group	Sample Size	Mean	90% Confidence Interval	Standard Error
R.1	3	624	412-836	49.2
R.2	27	669	652-687	8.6
2.1	2	561	300-821	20.5
2.2	24	684	673-695	5.2
2.2S1[a]	1		660	
3.1	8	598	533-663	27.5
3.2	58	672	663-680	4.4
Total	123	666	658-674	4.2

[a] Repeat spawner.

The number of post spawners immigrating through the weir the last 2 weeks of September was estimated at less than 200 fish (Table 3). Additional post spawners may have immigrated before (16 August to 15 September) or after (post 1 October) this time period. During 1989 (Larson 1990), the weir was operational as late as 6 November and a total of 692 Dolly Varden of varying size, or approximately 6% of the total immigration, entered the Anchor River after 15 August. Based on this evidence, the total post spawner immigrating component during 1992 is likely to be between 200 and 500 fish. A post spawner population of this magnitude could likely come from a relatively small stream system, perhaps Stariski Creek, a stream located about 7 miles north of the Anchor River mouth.

Major overwintering areas and movement patterns of lower Kenai Peninsula Dolly Varden are still not well understood. Dynamics of anadromous southern form Dolly Varden (Behnke 1980) populations are complex because they typically exhibit complicated migratory and homing patterns involving lake and non-lake watersheds (Armstrong 1965 and 1984; Sonnichsen 1990). Dolly Varden typically overwinter in lakes, but may spawn in either a lake system or a non-lake system. The Anchor River, which is the major study stream, is a non-lake system. Limited tagging data from 1987-1989 indicate that Dolly Varden interact with all local streams and range from the Kenai River drainage to the north and the English Bay drainage to the south and east of the Anchor River. Within this range there are several lake systems that could be major overwintering lakes, however, only English Bay lakes have a major anadromous Dolly Varden fishery (a spring subsistence fishery). Because this subsistence fishery is not sampled, fishing mortality due to this fishery, as well as other fisheries, is reflected in the "natural" mortality rates rather than the rates of fishing mortality. As a result, the importance of this lake system to all lower Kenai Peninsula Dolly Varden should be determined.

Examination of dynamic rates pertaining to Dolly Varden were first presented in 1991 (Larson 1992) and further examination of the historical data during 1992 (Tables 10-12) reinforced the basic premises deduced during 1991. They indicate that the Anchor River Dolly Varden stock has a high rate of turnover. To some extent, a high degree of fluctuation should be expected. These fish are fairly productive and the number of deaths due to fishing is much lower than from "natural" causes. The annual rates of fishing mortality reflect changes in availability of Dolly Varden to the fishery and changes in regulations. The number of fish available for harvest varies from year to year, depending on the run timing, as well as abundance. Over the past 5 years, the run timing has followed an alternating pattern of an early run one year and a late run the next. In 1988, 1990, and 1992, the Dolly Varden run was early, and fish were available for harvest over a longer time period. The run was late in 1989 and 1991. The annual rates of fishing mortality reflect differences in run timing, with higher rates in 1988, 1990, and 1992, and lower rates in 1989 and 1991. The decreased rates of fishing mortality in 1991 also probably reflect the decreased bag limit of two fish that year.

The effects from varying spawning escapements, documented since 1987, on recruitment will become evident over the next several years. The 1987 escapement will provide age-5 Dolly Varden to the fishery during 1993. This age group consists largely of spawners and should be reflective of Anchor River recruitment from the 1987 spawning escapement. By continuing this project, the necessary data will be provided to further model the dynamic rates (survival, recruitment, mortality) of Anchor River Dolly Varden and determine

if there is a relationship between the size of the spawning population and subsequent production. These estimates should be useful in developing appropriate regulatory measures.

Anchor River Steelhead

The Anchor River steelhead population is exhibiting signs of increasing abundance. Specifically, 1992 estimates for the Anchor River indicate a population of approximately 1,600 fish. This is a small but welcome increase from the 1,200 fish estimated in 1989 (Larson 1990) when the river was first restricted to catch-and-release fishing to conserve a resource which had been declining since the late 1970s.

The reasons behind the resurgence of steelhead to the Anchor River are not definitively known. These fish live at the northern edge of their range and population fluctuations are likely to occur naturally. The steelhead returning to the Anchor River during 1992 were primarily the progeny of the 1986 fall return and therefore not influenced by the 1989 harvest restrictions. Voluntary catch-and-release practices were increasing in popularity within the fishery prior to 1989 and may have influenced the 1992 return. By 1986, an estimated 60% of the Anchor River steelhead anglers were practicing catch-and-release fishing (Nelson et al. 1987). Assuming voluntary catch-and-release fishing by anglers in 1986 reduced the harvest, a greater number of steelhead would have been available to spawn in the spring of 1987, thereby contributing to the 1992 adult return.

Steelhead age analysis indicated only one steelhead to be a repeat spawner from a sample size of 123 fish. This indicates an exceptionally low return of repeat spawners. The estimated number of repeat spawners sampled intermittently since 1954 has varied from 3.5%-33.0% (Balland 1986) and averaged 18.8%. The low spawner return in 1992 was unexpected. There was empirical evidence of numerous post spawner steelhead emigrating in the spring of 1991 and 1992. For the last 2 years, the spring chinook salmon fishery intercepted seemingly numerous post spawned steelhead. Harvest of these fish was prohibited by regulation and, therefore, these fish were released. The sport interception of steelhead indicated these fish likely overwintered well but their absence as repeat spawners indicates they may have suffered from heavy post spawner mortality. Whether the mortality is a direct result of the sport interception, delayed spawning fatigue, or marine hardships has not been determined.

A Steelhead Planning Team was convened by Sport Fish Division Director Norval Netsch in 1988 and 1989. This planning team determined that the lower Kenai Peninsula streams of Anchor River, Ninilchik River, Stariski Creek and Deep Creek should be managed to maintain their wild steelhead populations. Until the Anchor River steelhead stocks rebuild to a minimum population of 2,500 adult fish, the planning team recommended the steelhead fishery be limited to catch-and-release fishing. The total estimated steelhead return of approximately 1,600 fish was 900 fish short of the recommended number of steelhead necessary to initiate possible changes in the current management strategy.

A weir count of Anchor River steelhead in 1995 is recommended. The results of steelhead catch-and-release regulations on the lower Kenai Peninsula, which began in 1989, will not be realized until 1995.

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APPENDIX A

Fishery, physical, and biological data

Appendix A1. Daily river water depth and temperature readings recorded at the Anchor River weir upstream trap, 1992.[a]

Date	Water Depth (cm)	Water Temp. (2200 hrs)	Thermograph Reading HIGHS (Celsius)	LOWS (Celsius)	Difference (Celsius)
03-Jul	8.5	16.5	18.0	15.5	2.5
04-Jul	8.5	17.0	18.1	12.7	5.4
05-Jul	9.0	15.0	16.0	12.8	3.2
06-Jul	9.0	13.0	13.3	11.1	2.2
07-Jul	9.3	13.0	12.5	10.5	2.0
08-Jul	9.8	13.0	12.0	10.3	1.7
09-Jul	10.0	13.0	12.8	10.9	1.9
10-Jul	9.5	13.0	12.5	11.2	1.3
11-Jul	9.5	13.0	14.9	11.3	3.6
12-Jul	10.0	15.0	14.6	11.4	3.2
13-Jul	9.0	15.0	15.0	11.2	3.8
14-Jul	10.0	13.0	13.3	11.9	1.4
15-Jul	10.5	13.0	13.5	11.1	2.4
16-Jul	11.5	14.5	16.0	11.2	4.8
17-Jul	11.0	13.5	13.7	12.0	1.7
18-Jul	16.0	13.0	12.9	10.2	2.7
19-Jul	15.0	12.5	15.1	10.3	4.8
20-Jul	12.5	14.0	15.5	10.7	4.8
21-Jul	11.0	14.0	13.6	11.8	1.8
22-Jul	11.0	13.0	12.7	10.9	1.8
23-Jul	11.0	13.0	12.9	10.9	2.0
24-Jul	11.0	13.0	13.6	11.0	2.6
25-Jul	11.0	13.0	12.8	11.1	1.7
26-Jul	11.0	13.0	13.0	10.1	2.9
27-Jul	13.5	12.0	12.7	10.3	2.4
28-Jul	12.5	12.0	11.8	10.5	1.3
29-Jul	14.0	12.0	12.0	10.3	1.7
30-Jul	15.0	13.0	13.7	9.5	4.2
31-Jul	14.0	12.0	12.0	9.8	2.2
01-Aug	12.5		12.2	9.3	2.9
02-Aug	12.0	13.0	12.2	9.1	3.1
03-Aug	13.0	13.0	11.7	10.4	1.3
04-Aug	15.5	13.0	12.2	10.4	1.8
05-Aug	15.0	12.5	12.0	10.6	1.4
06-Aug	14.0	12.0	12.0	10.6	1.4
07-Aug	14.0	13.0	13.0	10.4	2.6
08-Aug	12.5	15.0	15.3	10.0	5.3
09-Aug	12.0	15.0	15.0	11.3	3.7
10-Aug	11.0	14.0	13.3	11.0	2.3

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Appendix A1. (Page 2 of 3).

Date	Water Depth (cm)	Water Temp. (2200 hrs)	Thermograph Reading HIGHS (Celsius)	LOWS (Celsius)	Difference (Celsius)
11-Aug	11.0	14.0	12.4	10.8	1.6
12-Aug	11.0	12.0	11.0	10.0	1.0
13-Aug	10.5	13.0	13.6	9.4	4.2
14-Aug	10.0	12.0	11.8	8.2	3.6
15-Aug	10.0	12.0	10.7	9.7	1.0
16-Aug	11.5	11.0	10.5	9.3	1.2
17-Aug	13.0	12.0	12.7	8.3	4.4
18-Aug	11.5	13.0	13.3	9.4	3.9
19-Aug	10.5	13.0	11.8	9.8	2.0
20-Aug	10.0	12.0	10.7	9.6	1.1
21-Aug	10.0	12.0	10.9	9.3	1.6
22-Aug	10.0	12.0	11.0	9.5	1.5
23-Aug	10.5	11.5	11.0	9.6	1.4
24-Aug	11.5	11.0	11.0	9.8	1.2
25-Aug	12.5	11.0	10.4	8.8	1.6
26-Aug	22.0	11.0	10.7	8.8	1.9
27-Aug	15.5	10.5	9.2	8.3	0.9
28-Aug	13.0	11.0	9.9	8.2	1.7
29-Aug	12.0	11.0	10.8	7.0	3.8
30-Aug	13.5	10.0	9.6	8.8	0.8
31-Aug	16.0	10.0	10.7	8.2	2.5
01-Sep	13.5	10.0	9.2	7.7	1.5
02-Sep	12.0	9.0	10.7	7.5	3.2
03-Sep	12.0	10.5	10.0	6.0	4.0
04-Sep	11.5	9.0	8.6	7.2	1.4
05-Sep	14.0	9.0	8.2	7.3	0.9
06-Sep	16.0	8.0	7.7	5.9	1.8
07-Sep	14.0	8.0	8.4	5.0	3.4
08-Sep	13.0	8.0	8.8	5.5	3.3
09-Sep	13.0	7.5	7.9	5.1	2.8
10-Sep	12.0	7.0	6.7	4.2	2.5
11-Sep	11.5	7.0	6.0	2.7	3.3
12-Sep	11.0	7.0	6.4	3.8	2.6
13-Sep	11.0	7.0	7.7	5.2	2.5
14-Sep	11.0	7.0	8.8	6.0	2.8
15-Sep	11.0	5.0			
16-Sep	11.0	4.5			
17-Sep	11.0	6.0			
18-Sep	12.0	7.0			
19-Sep	13.0	6.5			

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Appendix A1. (Page 3 of 3).

Date	Water Depth (cm)	Water Temp. (2200 hrs)	Thermograph Reading HIGHS (Celsius)	LOWS (Celsius)	Difference (Celsius)
20-Sep	12.0	5.0			
21-Sep	10.5	4.5			
22-Sep	10.5	2.0			
23-Sep	11.0	2.0			
24-Sep	10.5	2.0			
25-Sep	10.5	2.0			
26-Sep	10.0	2.0			
27-Sep	10.5	2.5			
28-Sep	10.5	2.5			
29-Sep	10.0	1.0			
30-Sep	12.0	1.5			

[a] Water temperature was recorded both continually by thermograph and instantaneously by thermometer at 2200 hours, while river depth was instantaneously recorded at 2200 hours daily. River water depth was relative to a selected location on the upstream trap.

Appendix A2. Number of fish, by species and date, passed upstream through the Anchor River weir during 1992.

Date	Species[a]						
	DV	SS	PS	KS	RS	CS	SH
04-Jul							
05-Jul				1			
06-Jul	40		4	13			
07-Jul	44		4	1			
08-Jul	4		7	2			
09-Jul	24		4	2			
10-Jul	81		9	1	2		
11-Jul	75		7	6	1	1	
12-Jul	67		6	3	1		
13-Jul	161		8	5			
14-Jul	78		7	2			
15-Jul	482		8				
16-Jul	596		12	5	3	1	
17-Jul	824		9	8	1	2	
18-Jul	1,071		18	4			
19-Jul	302		10	6		2	
20-Jul	570		7	1	1		
21-Jul	336		6		1		
22-Jul	236		4		1		
23-Jul	263		5	1			
24-Jul	388		3	1			
25-Jul	468		9	2			
26-Jul	402		3	4	4		
27-Jul	434		17	9	2		
28-Jul	322		13	6	10		
29-Jul	278		10	2	3	1	
30-Jul	335	1	19	4	5		
31-Jul	89	1	2	2	9		
01-Aug	90		2		4		
02-Aug	118	1	5	2	4		
03-Aug	66	4	2	2	1		
04-Aug	59	8	12	20	5	1	
05-Aug	100	5	14	2	11	4	
06-Aug	63		18		4		
07-Aug	82	7	9	1	6		1
08-Aug	136	4	8		5	1	
09-Aug	54	8	8	1	3	1	1
10-Aug	33	6	7	2	1	1	
11-Aug	24	4	4		6	2	
12-Aug	31	11	6	1	4	2	

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Appendix A2. (Page 2 of 3).

Date	Species[a]						
	DV	SS	PS	KS	RS	CS	SH
13-Aug	46	9	7		3	1	
14-Aug	33	16	8		2		2
15-Aug	18	19	7	1	2		1
16-Aug	44	83	21	3	4	3	1
17-Aug	38	198	63	2	11	2	1
18-Aug	19	55	30		3	1	2
19-Aug	12	17	6		2		1
20-Aug	22	156	22		3	1	
21-Aug	18	202	18		7		4
22-Aug	15	327	36		2	4	16
23-Aug	32	210	20		5		14
24-Aug	19	523	58		15	1	16
25-Aug	13	365	85		1	1	17
26-Aug	2	21	6				
27-Aug	52	470	98	1	3	2	67
28-Aug	29	172	39		3		23
29-Aug	39	361	42				33
30-Aug	35	315	38				51
31-Aug	33	322	28				42
01-Sep	20	15	1		2		7
02-Sep	35	3			1		3
03-Sep	21	23	3		1	1	12
04-Sep	29	4					3
05-Sep	21	102	15				26
06-Sep	14	248	8		1		41
07-Sep	15	15	2				2
08-Sep	42	2	2			1	
09-Sep	15				1		3
10-Sep	13	1	1				
11-Sep	10		1				2
12-Sep	26	8	1				21
13-Sep	33	27	6				85
14-Sep	29	118	4				166
15-Sep	13						4
16-Sep	30				1		2
17-Sep	20		2				3
18-Sep	26	14	3				138
19-Sep	43	87	4				76
20-Sep	26						3
21-Sep	4						

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Appendix A2. (Page 3 of 3).

Date	Species[a] DV	SS	PS	KS	RS	CS	SH
22-Sep	6						
23-Sep	7						
24-Sep	11	1				1	13
25-Sep	45	5					168
26-Sep	27	1					15
27-Sep	37	3			1	1	12
28-Sep	57	15	1		2		110
29-Sep	30	3					41
30-Sep	1						11
01-Oct							1
Totals:	10,051	4,596	992	129	174	39	1,261

[a] Species: DV = Dolly Varden
SS = coho salmon
PS = pink salmon
KS = chinook salmon
RS = sockeye salmon
CS = chum salmon
SH = steelhead/rainbow trout

Appendix A3. Dolly Varden samples collected at random from the upstream trap of the Anchor River fish weir showing daily summaries of female gonad maturity and sex ratios, 1992.

	Female Maturity Index[a]					Sex Totals		
Date	1	2	3	4	5	Females	Males	Sample Size
15-Jul	4	40			22	66	47	113
16-Jul	1	5			0	6	1	7
30-Jul	14	37			15	66	54	120
11-Aug	4	2			0	6	6	12
12-Aug	8	3			5	16	14	30
13-Aug	11	3			2	24	22	46
14-Aug	15	2			3	20	13	33
25-Sep	0	0	2		0	2	1	3
29-Sep	0	0	0	6	8	14	6	20
TOTAL	57	92	2	6	47	220	164	384

[a] Maturity Index Codes:
1 = immature female with egg diameter less than 0.90 mm,
2 = mature female with egg diameter greater than 1.75 mm,
3 = completely mature female (eggs easily stripped),
4 = completely spawned female,
5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Appendix A4. Daily summary of Dolly Varden age compositions from fish sampled at random from the upstream trap of the Anchor River weir, 1992.

Date	Age Group 2	3	4	5	6	7	8	9	Daily Total
15-Jul	0	3	34	50	21	2	1	0	111
16-Jul	0	1	2	3	0	0	0	0	6
30-Jul	0	17	28	34	28	9	3	1	120
11-Aug	0	4	5	2	0	0	0	0	11
12-Aug	0	8	10	9	3	0	0	0	30
13-Aug	1	19	14	9	3	0	0	0	46
14-Aug	0	14	10	7	2	0	0	0	33
25-Sep	0	0	1	2	0	0	0	0	3
29-Sep	0	1	13	4	1	1	0	0	20
Totals:	1	67	117	120	58	12	4	1	380

Appendix A5. The daily and cumulative number of fish, by species, passed downstream through the Anchor River weir during 1992.

DATE	Dolly Varden		Chinook S.		Pink Salmon		Sockeye S.		Coho Salmon		Chum Salmon		Steelhead	
	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count
03-Jul		0	2	2		0	0		0		0		0	
04-Jul	3	3	3	3		0	0		0		0		0	
05-Jul	1	4	4	7		0	0		0		0		0	
06-Jul		4	3	10		0	0		0		0		0	
07-Jul	1	5		10		0	0		0		0		0	
08-Jul	1	6	1	11		0	0		0		0		0	
09-Jul	2	8	2	13		0	0		0		0		0	
10-Jul	2	10		13		0	0		0		0		0	
11-Jul	1	11	1	14	1	1	0		0		0		0	
12-Jul		11	1	15	1	2	0		0		0		0	
13-Jul	1	12	2	17	1	3	0		0		0		0	
14-Jul	1	13	1	18	2	5	0		0		0		0	
15-Jul	4	17	2	20	1	6	0		0		0		0	
16-Jul	8	25		20	1	7	0		0		0		0	
17-Jul	4	29		20	1	8	0		0		0		0	
18-Jul	7	36	8	28	1	9	0		0		0		0	
19-Jul	2	38	7	35	7	16	0		0		0		0	
20-Jul	1	39	2	37		16	0		0		0		0	
21-Jul	4	43	1	38	4	20	0		0		0		0	
22-Jul	6	49		38	1	21	0		0		0		0	
23-Jul	9	58	2	40	1	22	0		0		0		0	
24-Jul	11	69	1	41	4	26	0		0		0		0	
25-Jul	12	81	1	42	2	28	0		0		0		0	
26-Jul	1	82	4	46	7	35	0		0		0		0	
27-Jul	2	84	9	55	4	39	0		0		0		0	
28-Jul	7	91	10	65	1	40	0		0		0		0	
29-Jul	10	101	8	73	4	44	0		0		0		0	
30-Jul	8	109	11	84	6	50	0		0		0		0	

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DATE	Dolly Varden		Chinook S.		Pink Salmon		Sockeye S.		Coho Salmon		Chum Salmon		Steelhead	
	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count
31-Jul	8	117	13	97	2	52		0		0		0		0
01-Aug	8	125	13	110	5	57	1	1		0		0		0
02-Aug	6	131	15	125	11	68		1		0		0		0
03-Aug	8	139	6	131	11	79		1		0		0		0
04-Aug	12	151	13	144	10	89		1		0		0		0
05-Aug	1	152	20	164	11	100		1		0		0		0
06-Aug	13	165	13	177	4	104		1	2	2		0		0
07-Aug	13	178	19	196	17	121		1		2	1	1		0
08-Aug	15	193	9	205	12	133		1		2		1		0
09-Aug	9	202	13	218	16	149		1		2		1		0
10-Aug	11	213	5	223	7	156		1		2		1		0
11-Aug	9	222	4	227	6	162		1		2		1		0
12-Aug	9	231	2	229	8	170	3	4		2		1		0
13-Aug	18	249	2	231	10	180	1	5		2		1		0
14-Aug	13	262	4	235	7	187		5		2	1	2		0
15-Aug	7	269	1	236	4	191		5		2		2		0
16-Aug	3	272	4	240	3	194		5		2		2		0
17-Aug	14	286	2	242	14	208	1	6		2		2		0
18-Aug	16	302	4	246	9	217	1	7	1	3		2		0
19-Aug	15	317	1	247	12	229	1	8	1	4		2		0
20-Aug	12	329		247	3	232		8		4		2		0
21-Aug	8	337		247	8	240		8		4		2	1	1
22-Aug	4	341		247	13	253	1	9		4		2		1
23-Aug		341		247	5	258		9	2	6		2		1
24-Aug	13	354		247	24	282	2	11	4	10		2		1
25-Aug	9	363	3	250	20	302		11	1	11		2		1
26-Aug	33	396	22	272	35	337	1	12		11	2	4		1
27-Aug	3	399	2	274	10	347		12		11		4		1

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Appendix A5. (Page 3 of 4).

DATE	Dolly Varden		Chinook S.		Pink Salmon		Sockeye S.		Coho Salmon		Chum Salmon		Steelhead	
	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count
28-Aug	3	402		274	14	361		12	2	13		4		1
29-Aug	4	406		274	9	370	2	14		13		4		1
30-Aug	6	412		274	8	378		14		13		4		1
31-Aug		412	1	275	14	392		14		13		4		1
01-Sep	5	417	1	276	21	413		14		13		4		1
02-Sep	5	422		276	35	448		14		13		4		1
03-Sep	5	427		276	17	465	1	15	1	14		4		1
04-Sep	4	431		276	22	487		15	1	15		4		1
05-Sep	2	433		276	11	498		15	1	16		4		1
06-Sep	6	439	1	277	26	524		15	3	19		4		1
07-Sep	4	443		277	25	549	1	16	1	20		4		1
08-Sep	4	447		277	16	565		16	2	22		4		1
09-Sep	3	450		277	18	583		16	7	29		4	1	2
10-Sep		450		277	9	592		16		29		4		2
11-Sep	3	453		277	10	602	1	17	1	30		4		2
12-Sep		453		277	2	604		17	1	31		4		2
13-Sep	1	454		277	2	606		17	1	32		4		2
14-Sep		454		277		606		17		32		4		2
15-Sep		454		277	6	612		17	1	33		4	1	3
16-Sep	1	455		277	3	615		17		33		4		3
17-Sep	2	457		277	2	617		17		33		4		3
18-Sep	1	458		277	3	620		17	1	34		4		3
19-Sep		458		277	2	622	1	18	2	36		4		3
20-Sep	1	459		277	1	623	1	19	1	37		4		3
21-Sep	1	460		277	3	626	1	20	1	38		4		3
22-Sep	1	461		277	1	627		20		38		4		3
23-Sep	2	463		277	1	628		20	1	39		4		3
24-Sep	1	464		277	1	629		20		39		4		3

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Appendix A5. (Page 4 of 4).

DATE	Dolly Varden		Chinook S.		Pink Salmon		Sockeye S.		Coho Salmon		Chum Salmon		Steelhead	
	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count
25-Sep		464		277		629		20		39		4	1	4
26-Sep		464		277		629		20		39		4		4
27-Sep	3	467		277		629	1	21		39		4	1	5
28-Sep	4	471		277	1	630		21		39		4		5
29-Sep	7	478		277	2	632		21		39		4		5
30-Sep	4	482		277	1	633		21	1	40		4		5
01-Oct	23	505		277		633		21	1	41		4		5